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Adaptation and verification of malt sorghum (*Sorghum bicolor* (L.) Moench) genotype in drought prone areas of Ethiopia

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Sorghum grain is being used predominantly as a food grain crop and the lion share of the grain production is consumed at the household level. Ethiopia is demanding huge amount of malt barley for the national beer production; unfortunately, the production area is not proportionally increasing with demand and the supply of malt barley is by far lower than the demand. Currently, however, there is a room to accommodate market oriented activities such as the development of malt sorghum varieties. It has been speculated that the demand for malting type sorghum will be increased for the reason that sorghum is climate resilient crop and the area for barley production is not growing with malt demand. Hence, selecting genotypes meeting the specific malt quality to save foreign currency used to import malt barley and improve livelihood of sorghum farmers. There was an attempt to develop malt sorghum varieties by national sorghum improvement program. Currently, a variety called Debir, which was identified as a potential candidate for adaptation trial. This candidate variety has good grain yield potential with acceptable protein content which is really very important trait for beer making quality. Moreover, Meta brewery factory has been identified this candidate variety as suitable for malting and have great interest to use as an ingredient for the brewery industry in Ethiopia. Therefore, in 2017 crop season the grain yield performance of the variety has been tested in six major sorghum testing sites and twenty one (21) locations both on farm and on station. Considering the potential use of the variety for the brewery industry and grain yield the national sorghum research program presented so that the field performance and adaptability of the candidate genotypes along with the standard check were evaluated by the national variety releasing technical committee. Finally, 2018 G.C, the standing committee approved the release of Dabir variety for commercial production. In general, this variety was recommended for lowland areas (500-1600masl) of Ethiopia with annual rainfall of 500-870mm and farmers can be benefited from production and sell of this variety to the brewery factories.

Key words: Grain yield, malt sorghum, brewery industry

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INTRODUCTION

Sorghum [*Sorghum bicolor* (L.) *Moench*] is a C4 tropical crop (Smith and Frederiksen, 2000). It is an indigenous crop to Ethiopia where it is grown in a wider area of adaptation ranging from hot, dry lowland, intermediate to the highland environments. Sorghum is among the most important crops cultivated in Ethiopia with most of the acreages located in parts of the country affected by frequent drought and marginal soils. In Ethiopia, the crop grown entirely by subsistence farmers to meet needs for food, income, feed, traditional brewing and construction purposes. Sorghum is the second preferred cereal after tef for preparing 'injera', which is the staple food in Ethiopia. It contributes significantly to the protein and energy requirements for millions of people mainly living in Sub Saharan Africa and Asia (Elkhier and Hamid, 2008; Ali *et al*., 2011; Orr *et al*., 2016). In the developed countries there has been increased interest in sorghum as a gluten-free cereal to substitute the gluten rich cereals in the diet of people suffering from celiac disease (Fenster, 2003; Delserone, 2007) and biofuel production (Ahmad Dar, 2017).

Sorghum accounts for 66% of the total cultivated areas of the country and the national average productivity of sorghum in Ethiopia is 2.7 tons/ha (CSA, 2017/18). The world sorghum production is estimated to be 62.3 million tons from 42 million hectares of land. In Africa, sorghum production is 29.14 million tons from 26.03 hectares of land (USDA, 2017). Sorghum is the fifth and the third major cereal in the world and in Ethiopia, respectively based on total area and production. In Ethiopia, it ranks third in area coverage, after maize and teff (CSA, 2017/18). Currently the area covered with sorghum in Ethiopia is 1.9 million ha, and its total production is 5.1 million tons of grain (CSA, 2017/18). The global annual sorghum grain production is over 63.08 million metric tons, while in Africa a total 24.1 million metric tons. This makes sorghum quantitatively the second most important cereal grain in Africa after maize. Nigeria, Sudan, and Ethiopia are the major sorghum producers in Africa, which accounted 64.73 % in the total sorghum production.

Sorghum is one of the major staple food crops on which the lives of millions of Ethiopians depend. The majority of grain production goes for the preparation of diverse food recipes, like porridge,*"injera", "Kitta", "Nifro",* infant food and syrup (Asfaw, 2007). A small fraction of of the grain it is being malted for local beverages, such as making traditional distilled (*Arake*) and undistilled (e.g., *Tella* and *Borde*) (Abegaz *et al*., 2002). Regardless of the availability of several other cereal types, barley is the grain of choice when it comes to malting in modern brewing (Taylor and Dewar, 2000). In tropical Africa, however, barley cultivation has not seen any success. Thus, industries that use malt barley as their major raw materials are relying on imports of this grain. This is still problem to the brewing industries and also to the economies of mostly tropical African countries. For this reason some tropical cereals (wheat, rye, oat, maize and sorghum) have been investigated for their malting properties (Agu and Palmer, 2013). Next to barley, sorghum malt is the most appropriate alternative for brewing (Shambe *et al*., 1989; Taylor *et al*., 2006; Ogbonna, 2011).

Sorghum has been used for brewing beer in Africa for ages, mainly for producing opaque beer in many parts of Sub-Saharan Africa. Brewing clear lager beer from sorghum was put on Throughout Sub-Saharan Africa, sorghum is the grain of choice to produce traditional alcoholic and non- alcoholic beverages, traditional cloudy and opaque (sorghum) beers. The key ingredient of these beers being sorghum malt, which provides hydrolytic enzymes (especially amylases to ferment sugars into ethanol and carbon dioxide), starch (the source of fermentable sugars), yeast nutrients and beer flavor and color substances (Dewar*,* 2003; Taylor, 2003).

Ethiopia is demanding huge amount of malt barley for the national beer production; unfortunately, the production area is not proportionally increasing with demand and the supply of malt barley is by far lower than the demand. The domestic malt factories (Asela and Gondar) cover 65 % of the country's malt demand. Thus, the country is importing massive amount of malt barley and only in the first 8 months of 2016 imported 65,180 tons barley malt (USDA, 2017). Until recently, only two malt sorghum varieties (Red Swazi and Macia) have been released by the national sorghum research program and little efforts have been made to promote the varieties to be used by the brewery industries and the landraces were not exploited to be used as malt (Assfaw *et al*., 2011). As compared to many African countries like Nigeria and South Africa, Ethiopia is far behind in using sorghum malt in the production of beer. This is mainly due to sorghum industrial processing is largely missed (malting industries) (EIAR, 2014), high demand of sorghum grain for food, and lack of access for potential malt sorghum varieties. For the first time sorghum is used as a beer ingredient in the form of adjunct in Ethiopia by Meta Beer company (subsidiary of Diageo) in 2016. The sorghum and barley product Azmera beer is currently in production.

Eventhough, Ethiopia is the centre of origin with diverse genetic resources of sorghum; several improved food sorghum varieties are adapted to semi arid tropical regions; still the landraces are not extensively characterized, exploited for their malting potential and considerable scope remains to use in the brewing industries (Asfaw, 2007). Over the years, the focus of sorghum research in Ethiopia has been on improving the

grain yield through breeding, soil fertility management and crop protection and less attention has been paid to quality traits. Currently, however, there is a room to accommodate market oriented activities such as the development of malt sorghum varieties and activities linked to other industrial uses such as the development of sweet sorghum varieties for bioethanol production.

It has been speculated that the demand for malting type sorghum will be increased for the reason that sorghum is climate resilient crop and the area for barley production is not growing with malt demand. Hence, selecting genotypes meeting the specific malt quality to save foreign currency used to import malt barley and improve livelihood of sorghum farmers. Therefore, the objective of this study was:-

- To assess the adaptability and field performance candidate malt sorghum genotypes
- To verify the candidate genotypes for commercial production foe commercial production

MATERIALS AND METHODS

The details of the genotypes used and methods followed for traits/data collection and analysis of data and interpretations are described in this chapter. The field experiment was carried out in six environments during the main cropping season in 2017.

Description of test genotypes

A total of 3 genotypes and one popular released variety Melkam as a standard check were in this malt sorghum variety verification study. The candidate malt sorghum genotypes was the land race collection of Ethiopia. (Table 1)

Table 1. List of sorghum genotypes used for this study and their origin

Entry #	Genotype	Pedigree	Seed source
1	Dabir	Landrace collection	Melkassa ARC
2	Macia	Introduced released variety	Melkassa ARC

Experimental design and methods

Based on their yield performance and uniformity during the preliminary observation nursery at Melkassa, among the evaluated 3 genotypes Dabir variety has been selected for the next season on farm adaptation and verification trial that was conducted in 2017 at twenty one (21) locations both on farm and on station: Mieso(3 location), Sheraro(3 location), Shoarobit (3 location), Erer(3 location), Humeraa(3 location) and Kobo(3 location). In general a total of twenty one trials were conducted in seven major sorghum testing environments. Each plot of the candidates and the standard check varieties had 13 rows of 10 m length with row spacing of 75 cm.

Trial management

As per the recommendation for sorghum production in the lowland areas of Ethiopia, Diammonium phosphate (DAP) and urea (Nitterohen) were applied at the rate of 100 kg/ha and 50 kg/ha, respectively. Di-ammonium phosphate was applied by incorporating into the soil during planting of the seeds and Urea was applied as side dressing at knee height stage (35 days) after planting of the seed. Thinning was done after three weeks of planting to maintain the space between plants and to balance the plant density. Other crop management practices were applied following the recommended practices.

Data collection

The following data were collected and used to evaluate the adaptability performance and verify the candidate variety.

Days to 50% flowering – The time between days to emergence until 50% of the plants in a plot reached half-bloom stage.
Plant height (cm) – The length from the base of the plant to the tip of the panicle
Grain yield per plot (GY): Grain yield in kilogram of plants from the three rows and adjusted to 10% moisture level and converted to kg ha-1.
Days to 90% physiological maturity (DTM): The number of days from planting to the stage
when 90% of the plants in a plot when reach to physiological maturity, i.e., the stage at which when the panicle lose their pigmentation and begin to dry.
Plant aspect (PAS): Over all agronomic desirability score (drought tolerance, earliness, head exertion and compactness, grain size and shape, thresh ability, disease and insect resistance, etc) was measured using 1-5 score where 1=excellent and 5=poor; data scored by the same individual across sites and year were preferably used for this analysis
Protein content (%): The amount of protein content detected on the grain to make sure the genotypes are suitable for malting
Thousand seed weight (%): Weight of 1000 seeds in gram that was measured from each plot after the moisture level adjusted to 10%.

RESULT AND DISCUSSIONS

Ethiopia is demanding huge amount of malt barley for the national beer production; unfortunately, the production area is not proportionally increasing with demand and the supply of malt barley is by far lower than the demand. Currently, however, there is a room to accommodate market oriented activities such as the development of malt sorghum varieties. It has been speculated that the demand for malting type sorghum will be increased for the reason that sorghum is climate resilient crop and the area for barley production is not growing with malt demand. Hence, selecting genotypes meeting the specific malt quality to save foreign currency used to import malt barley and improve livelihood of sorghum farmers. There was an attempt to develop malt sorghum varieties by national sorghum improvement program. Currently, a variety called Debir, which was identified as a potential candidate for adaptation trial. This candidate variety has good grain yield potential with acceptable protein content which is really very important trait for beer making quality. Moreover, Meta brewery factory has been identified this candidate variety as suitable for malting and have great interest to use as an ingredient for the brewery industry in Ethiopia. Therefore, in 2017 crop season the grain yield performance of the variety has been tested in seven major sorghum testing sites and twenty one (21) locations both on farm and on station. Considering the potential use of the variety for the brewery industry and grain yield the national sorghum research program presented so that the field performance and adaptability of the candidate genotypes along with the standard check were evaluated by the national variety releasing technical committee. Finally, 2018 G.C, the standing committee approved the release of Dabir variety for commercial production. In general, this variety was recommended for lowland areas (500-1600masl) of Ethiopia with annual rainfall of 500-870mm and farmers can be benefited from production and sell of this variety to the brewery factories.

Merits of the released variety

Debir variety is preferred for its good malting quality grains and yields 47.8 q/ha in research and 37 q/ha on farmers' field. Plant height ranges from 130cm to 145cm suitable for combine harvesting in commercial farms. The variety matures very early (85-103days) so that it can escape late coming drought and also for large scale commercial farming it can be produced three times per year using irrigation. Moreover, the variety has an excellent sorghum diastetic unit per gram (DU/g), which is one of the most important criteria to select varieties for their malting quality. In addition to its good malting properties, the variety is preferred for its excellent injera making quality. The farmer preferred this variety based on the overall performance and agronomic desirability score which signifies thresh ability, head size , grain color of the variety.

Main characteristics of the released malt sorghum variety (IPGR descriptors, 1993)

1. **Variety**: Mentebteb(Dabir Malt sorghum)
2. **Agronomic and Morphological Characteristics**

- **Adaptation Area:** West & East Hararge, North Showa, North & South Wello, South Tigray, North West Tigray, Gonder and similar agro-ecologies
- Altitude (masl): <1600
- Rainfall(mm): <600
- Seed rate (kg/ha):10-12 for row sowing
  - Spacing(cm): 75cm between rows
  - Planting date: Mid June to early July
  - Fertilizer rate(kg/ha):
    - DAP: 100
    - Urea: 50
  - Days to flowering: **67** days
  - Days to Maturity: **103:00**
  - Plant height(cm): **145.00**
  - 1000 seed weight (g):**31.00**
  - Seed color: White
  - Protein :9:60
  - Inflorescence compactness and shape: Semi Compact
  - Crop pest reaction: Tolerant to major insect and disease of Sorghum
  - Grain yield (qt/ha):
    - On-station: **47.80**
    - On farmers field: **37.00**

3. Year of release: 2018 G. C
4. Breeder/ maintainer: Melkassa agricultural research center (MARC)

CONCLUSION

Sorghum is an indigenous crop to Ethiopia where it is grown in a wider area of adaptation ranging from hot, dry lowland, intermediate to the highland environments. Sorghum is among the most important crops cultivated in Ethiopia with most of the acreages located in parts of the country affected by frequent drought and marginal soils. In Ethiopia, the crop grown entirely by subsistence farmers to meet needs for food, income, feed, traditional brewing and construction purposes. Ethiopia is demanding huge amount of malt barley for the national beer production; unfortunately, the production area is not proportionally increasing with demand and the supply of malt barley is by far lower than the demand. The domestic malt factories (Asela and Gondar) cover 65 % of the country's malt demand. Thus, the country is

importing massive amount of malt barley and only in the first 8 months of 2016 imported 65,180 tons barley malt (USDA, 2017). It has been speculated that the demand for malting type sorghum will be increased for the reason that sorghum is climate resilient crop and the area for barley production is not growing with malt demand.

Hence, to identify genotypes meeting the specific malt quality to save foreign currency used to import malt barley and improve livelihood of sorghum farmers in 2017 crop season the adaptation trails I have been conducted in six major testing sites and twenty one (21) locations at the same time the laboratory work has been done in the same year. The variety was preferred for its good malting quality grains and also grain yields 47.8 q/ha at research station and 37 q/ha on farmers field condition. Moreover, the variety has an excellent sorghum diastetic unit per gram (DU/g) and low protein content, which is one of the most important criteria to select varieties for their malting quality. In general, this variety was recommended for lowland areas (500-1600masl) of Ethiopia with annual rainfall of 500-870mm. The small holder farmers can improve income by growing this variety both as grain and cash crop. In general the released variety could be used as best option for making malt and significantly contribute to save foreign currency that the country used to import malt barley and improve livelihood of sorghum farmers.

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